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Method and apparatus for determining the thickness of a dielectric layer

The invention relates to a method for determining the thickness of a dielectric layer comprising the steps of providing an electrically conductive body having a dielectric layer, a surface of the dielectric layer being exposed, depositing an electric charge onto the exposed surface thereby inducing an electric potential difference between the exposed

5   surface and the electrically conductive body, determining an electric parameter relating to the electric potential difference, and deriving the dielectric layer thickness from the electrical parameter.

The invention further relates to a method for manufacturing an electric device in which such a method is performed.

10   The invention relates further to an apparatus for determining the dielectric layer thickness according to such a method.

WO 02/059631 discloses a method for determining the thickness of a

15   dielectric layer as described in the opening paragraph.

In the known method, an electric charge dQ_C is deposited onto the exposed surface of the dielectric layer. Due to the deposited electric charge dQ_C an electric potential difference dV between the exposed surface and the electrically conductive body is induced. An electrical parameter relating to this electric potential difference is determined by a Kelvin

20   probe or a Monroe probe and subsequently the thickness of the dielectric layer is determined from the electrical parameter. The electrical parameter may be the electric potential difference dV itself or alternatively, e.g., a leakage current through the dielectric layer. The leakage current may be time-dependent.

It is a disadvantage of the known method that the thickness of the dielectric

25   layer cannot be determined when the dielectric layer is separated from the electrically conductive body by at least one further dielectric layer.

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It is an object of the invention to provide a method which is suited to determine the thickness of the dielectric layer when the dielectric layer is separated from the electrically conductive body by at least one further dielectric layer.

The invention is defined by the independent claims. The dependent claims
5   define advantageous embodiments.

The invention is based on the insight that in the known method the thickness d_1 of the dielectric layer cannot be determined when the dielectric layer is separated from the electrically conductive body by at least one further dielectric layer because the electrical parameter then is a function of the thickness d_1 and the thickness d_2 of the at least one further
10   dielectric layer. In the remainder of this document the at least one further dielectric layer is often referred to simply as the further dielectric layer. When the at least one further dielectric layer comprises more than one layer, the thickness d_2 comprises the thickness of each of these layers. By performing the measurement, measurement data being a further function of the thickness d_2 are obtained. The measurement data may additionally depend on the
15   thickness d_1 as well provided that the dielectric layer thickness, which is selected from the thickness d_1 and the thickness d_2, is derivable from the electric potential difference and the measurement data. This implies that the electrical parameter and the measurement data have different functional dependencies on the thickness d_1 and the thickness d_2 such that at least one of the unknowns, i.e. the thickness d_1 and/or the thickness d_2, can be determined from the
20   electrical parameter and the measurement data.

The measurement may comprise, e.g., a mechanical, optical or electrical measurement of the thickness d_1, the thickness d_2 or the thickness d_1 plus the thickness d_2.

In the method according to the invention the electrically conductive body may comprise, e.g., metals, metal alloys, semiconductors or layers of these materials. The
25   dielectric layer and the further dielectric layer may comprise any type of electrically insulating material such as, e.g., silicon oxide, silicon nitride, tantalum oxide, aluminum oxide, barium strontium titanium or hafnium oxide.

The method according to the invention is further suited for determining the thickness d_2 instead of or in addition to determining the thickness d_1.

30   The method according to the invention is particularly useful for dielectric layers having a relatively small thickness of, e.g., 10 nm or less. In particular for layers of such small thickness alternative techniques are often not reliable and/or not accurate.

In an embodiment the dielectric layer has a dielectric constant ε_1, the further dielectric layer has a further dielectric constant ε_2, and the dielectric layer thickness, e.g. the

thickness d_1, is determined from the thickness d_2, the dielectric constant ε_1, the further dielectric constant ε_2, the electric charge dQ_C and the electric potential difference dV. Neglecting current leakage through the dielectric layer and the further dielectric layer, dV as a function of dQ_C, which is also referred to as the Q-V relationship, is used to derive the

5   equivalent capacitance density C/A, i.e. the capacitance C per area A. From the equivalent capacitance density C/A the thickness d_1 is derivable by using the formula $\varepsilon_0\, A/C = (d_1/\varepsilon_1 + d_2/\varepsilon_2)$, where ε_0 denotes the permittivity of free space. When the further dielectric layer comprises a stack of n layers, where n is an integer larger than one, each of the layers having a thickness d_{i+1} with a dielectric constant ε_{i+1}, where i is a positive integer smaller than or

10   equal to n, the term d_2/ε_2 in the above formula is replaced by the sum of all terms d_i/ε_i. When current leakage through the dielectric layer and the further dielectric layer cannot be neglected, the electric potential difference depends on time. In this case the thickness d_1 can be determined from, e.g., the measured electric potential difference as a function of time by analyzing it analogously to the known method.

15   Alternatively, in particular in cases where the thickness d_2 is not readily available, other methods of performing the measurement may be advantageous which may be based on, e.g., the spectral reflectance of the dielectric layer and/or of the further dielectric layer. This method of determining the thickness d_1 and the thickness d_2 by measuring the spectral reflectance is known from, e.g., US-4,999,509. It involves measuring the spectral

20   reflectance, i.e. the ratio of the reflected light intensity and the incident light intensity as a function of the wavelength. The measurement data thus obtained are then analyzed using an optimization procedure the outcome of which at least partly depends on the initial parameters used in the optimization procedure. Therefore, this technique alone is often not sufficiently reliable and/or accurate, in particular when the dielectric layer and the further dielectric layer

25   are relatively thin, e.g. having a thickness of less than 50 nm such as, e.g. 2 to 10 nm, or when the further dielectric layer and the electrically conductive body are separated by an additional dielectric layer. When this method is used in combination with the known method, the electrical parameter imposes a constraint during the optimization procedure, thereby largely reducing the above-mentioned dependency on the initial parameters used in the

30   optimization procedure.

It is often advantageous if after depositing the electric charge dQ_C and determining the electrical parameter, and prior to performing the measurement, the dielectric layer is at least partly removed to expose a further surface of the further dielectric layer.

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When the further dielectric layer comprises more than one layer, the upper of these layers, i.e. the layer in direct contact with the dielectric layer, is exposed. In this way it is possible to perform the measurement on the exposed part of the further dielectric layer, i.e. at a position where the dielectric layer is absent. As a consequence, the measurement data relate to a

5   relatively small extent to the thickness d_1, allowing for a computationally relatively easy determination of the thickness d_1. When partly removing the dielectric layer, it is preferred that the measurement data relate to the thickness d_1 as little as possible, i.e. not at all.

In this case it is further advantageous if the thickness d_2 of the exposed part of the further dielectric layer remains substantially constant during the step of at least partly

10   removing the dielectric layer because the measurement data then directly relate to the thickness d_2. When a part of the further dielectric layer is removed as well during the step of at least partly removing the dielectric layer, the remaining exposed further dielectric layer is thinner than the further dielectric layer when determining the electrical parameter. For a reliable determination of the thickness d_1 this reduction of the thickness d_2 has to be taken

15   into account which complicates the execution of the method according to the invention.

In many cases it is advantageous if the step of at least partly removing the dielectric layer comprises an etching step because for many material combinations etching recipes are known which allow for selectively removing at least part of the dielectric layer while keeping the thickness d_2 substantially unchanged.

20   When at least partly removing the dielectric layer to at least partly expose the further dielectric layer it is further advantageous if performing the measurement comprises the sub-steps of depositing a further electric charge onto the further exposed surface, thereby inducing a further electric potential difference between the further exposed surface and the electrically conductive body, and determining a further electrical parameter relating to the

25   further electric potential difference, the measurement data comprising the further electrical parameter. In this embodiment of the method according to the invention the thickness d_2 of the exposed further dielectric layer is determined in a way analogous to the known method which has the advantage that the thickness d_2 is determined relatively accurately, in particular when the thickness d_2 is relatively small, e.g. below 50 nm. For such a relatively small

30   thickness alternative methods often do not have the required accuracy.

In another embodiment of the method according to the invention the electrically conductive body and the further dielectric layer are separated by an additional dielectric layer, i.e. the dielectric layer, the further dielectric layer and the additional dielectric layer initially form a stack, and the measurement data relate to a thickness d_3 of the

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additional dielectric layer. When leakage currents through the dielectric layer, the further dielectric layer and the additional dielectric layer can be neglected, the thickness d_1 is readily derivable from the formula $\varepsilon_0\, A/C = (d_1/\varepsilon_1 + d_2/\varepsilon_2 + d_3/\varepsilon_3)$ where ε_3 denotes the dielectric constant of the additional dielectric layer and A/C is the inverse of the equivalent capacitance

5   density C/A.

It is often preferred that the thickness d_2 and the thickness d_3, if present, are determined as well when executing the method according to the invention.

Alternatively, in particular in cases where the thickness d_2 and/or the thickness d_3 are not readily available, other methods of performing the measurement may be

10   advantageous which may be based on, e.g., the spectral reflectance of the dielectric layer and/or of the further dielectric layer.

In many cases it is advantageous if performing the measurement comprises determining a spectral reflectance of the exposed surface and/or of a further exposed surface of the further dielectric layer. This method is well known in the art and by combining it with

15   the method known from WO 02/059631, the ambiguities in analyzing the data by this method are reduced as explained above. The combination of the method known from WO 02/059631 with the method of determining the spectral reflectance is in particular advantageous when the electrically conductive body and the further dielectric layer are separated by an additional dielectric layer. It is often impossible to use the latter method alone on a stack comprising

20   three or more dielectric layers whereas this is possible using the method according to the invention.

In one embodiment, the spectral reflectance data of the entire stack of the at least three layers are analyzed using the determined electrical parameter as a constraint in the analysis. In another embodiment the dielectric layer is at least partly removed after having

25   determined the electrical parameter, the further dielectric layer is at least partly exposed prior to performing the measurement of the spectral reflectance of the at least partly exposed further dielectric layer. This latter embodiment has the advantage that the analysis of the spectral reflectance data is relatively easy because it involves only two instead of three dielectric layers, i.e. only the further dielectric layer and the additional dielectric layer.

30   The method for determining the dielectric layer thickness is advantageous when executing a method for manufacturing an electric device comprising an electrically conductive body having a dielectric layer, the dielectric layer being separated from the electrically conductive body by at least one further dielectric layer. The method of manufacturing an electric device comprises the steps of providing the electrically conductive

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body with the at least one further dielectric layer, providing the at least one further dielectric layer with the dielectric layer, and performing the method for determining the dielectric layer thickness according to the invention for monitoring the steps of providing the electrically conductive body with the at least one further dielectric layer and/or of providing the at least

5   one further dielectric layer with the dielectric layer.

Many electric devices such as, e.g., transistors have a dielectric layer which may be, e.g., a gate dielectric arranged between a semiconducting substrate and a gate electrode, or an inter-gate dielectric arranged between a floating gate and a control gate in a non-volatile memory device. Often, these dielectric layers comprise two or three, sometimes

10   even more, separate layers stacked onto each other. Examples are stacks of layers of silicon oxide and silicon nitride, which are often simply referred to as an ON layer, and of silicon oxide, silicon nitride and silicon oxide, which are often simply referred to as an ONO layer. Other examples are stacks of layers at least one of which comprises a dielectric material having a dielectric constant higher than that of silicon dioxide such as, e.g., tantalum oxide,

15   hafnium oxide, zirconium oxide and aluminum oxide. These materials, which in the art are referred to as high-k materials, often cannot be in direct contact with semiconductors or metals. Therefore, they are often applied in stacks comprising, e.g., a silicon oxide layer interposed between the high-k material and the electrically conductive body.

To obtain a reliable electric device each of the dielectric layers in the stack has

20   to have a thickness within a particular range. During manufacture of electric devices the thickness of each of these layers has to be monitored accurately. It is then preferred that the thickness d_2 and the thickness d_3, if present, are determined as well when executing the method according to the invention.

Performing the method for determining the dielectric layer thickness according

25   to the invention during the manufacture of an electric device has the advantage that the dielectric layer, the further dielectric layer and the additional dielectric layer, if present, can be formed subsequently in one tool without the need of removing the conductive body after depositing one of the dielectric layers for measurement purposes before forming the subsequent dielectric layer.

30   According to the invention the dielectric layer thickness may be determined on a separate electrically conductive body such as, e.g. a test wafer which is processed at the same time in the same chamber as one or more other electrically conductive bodies comprising the pre-fabricated electric device. Alternatively, the dielectric layer thickness may be determined on the same electrically conductive body as that which comprises the pre-

fabricated electric device. The latter embodiment is preferred in a process in which the electrically conductive bodies are processed one by one, so-called single wafer processing.

The apparatus for determining the dielectric layer thickness according to the method of the invention comprises a charge source for depositing the electric charge, a

5   measuring device for determining the electric parameter relating to the electric potential difference, and a signal processor means for determining the dielectric layer thickness from the electrical parameter and the measurement data. Preferably, the signal processor is arranged to determine the thickness d_1, the thickness d_2 and the thickness d_3, if applicable.

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These and other aspects of the method and the apparatus for determining the thickness of the dielectric layer, and of the method for manufacturing an electric device according to the invention will be further elucidated and described with reference to the drawings, in which:

15   Fig. 1 is a schematic drawing of a cross-section of the apparatus for determining the dielectric layer thickness, and

Figs. 2A–2D are cross-sections of the electrically conducting body at various steps of an embodiment of the method for manufacturing the electric device.

The Figures are not drawn to scale. In general, identical components are

20   denoted by the same reference numerals.

The method for determining a dielectric layer thickness comprises the steps of providing an electrically conductive body 11 shown in Fig. 1 which may be, e.g., a silicon

25   wafer, a silicon on insulator wafer or a gallium arsenic wafer. The electrically conductive body 11 is held by and electrically connected to a conductive vacuum chuck 18 which is electrically connected to ground potential. The electrically conductive body 11 has a dielectric layer 13 which may be composed of any type of electrically insulating material such as, e.g., silicon oxide, silicon nitride, tantalum oxide, aluminum oxide, hafnium silicate,

30   zirconium oxide, lanthanum oxide, praseodium oxide (Pr_2O_3), barium strontium titanium or hafnium oxide. The dielectric layer 13 is separated from the electrically conductive body 11 by at least one further dielectric layer 3 which may be composed of any type of electrically insulating material such as, e.g., the materials mentioned above in relation to dielectric layer 13. The dielectric layer 13 has a surface 15 which is exposed.

In a step of the method according to the invention an electric charge dQ_C is deposited onto the exposed surface 15, thereby inducing an electric potential difference dV between the exposed surface 15 and the electrically conductive body 11. The electric potential difference dV is a function of the thickness d_1 of the dielectric layer 13 and the

5   thickness d_2 of the further dielectric layer 3.

The apparatus 10 for determining the dielectric layer thickness shown in Fig. 1 is similar to that shown in Fig. 1 of WO 02/059631. It comprises a charge source 16 for depositing the electric charge dQ_C. The charge source 16 may be, e.g., a corona discharge source including a corona charging wire 14a which receives a high voltage potential of either

10   a positive or negative polarity and a corona-confining electrode ring 14b, e.g., a metal ring, held at ground potential or a bias. Preferably, the charge source 16 is able to deposit the charge dQ_C uniformly on the surface 15 of the dielectric layer 13, preferably within a radius of about 6 to about 10 mm. The corona discharge source is able to produce a controlled ionic discharge flux (ionic) current suitable for depositing the electric charge dQ_C. The flux may be

15   adjustable and range, e.g., from about 10^{-6} to about 5×10^{-6} A cm^{-2}.

Preferably, the amount of the deposited charge dQ_C is relatively small, e.g. determined by the above-specified flux which is deposited during less than, e.g., 30 seconds. In this way the amount of charged traps generated in the dielectric layer 13 and the further dielectric layer 3 due to the current leakage is reduced which enhances the accuracy of the

20   method. The amount of the electric charge dQ_C deposited may be controlled by adjusting the high voltage potential, the height of the corona electrode above the wafer, and/or the bias voltage applied between the corona charging wire 14a and the ion flux confining electrode 14b. The charge source 16 is able to deposit either a positive or a negative charge on the surface 15. Preferably, the charge source 16 charges the surface 15 with a positive corona

25   discharge because a negative corona discharge is more difficult to control with respect to charging uniformity.

In a subsequent step an electric parameter relating to the electric potential difference dV due to the deposition of the electric charge dQ_C is determined. To this end the apparatus 10 further comprises a measuring device 22 for determining the electrical

30   parameter relating to the potential difference dV. The potential measuring device 22 may be, e.g., a Kelvin probe or a Monroe-type probe. It is able to determine the electric potential difference dV by measuring the contact potential of dielectric layer 13 with respect to a reference electrode 30. Sensors of these types are described, e.g., in the references stated in

WO 02/059631, page 9, line 28–31. Typically, the electrode 30 is separated from the top surface of the dielectric film 13 by an air gap of about a fraction of about a millimeter. Charge source 16 and measuring device 22 are spaced apart from each other on a mount at a fixed distance x_0 of , e.g., 2 cm, between their centers. After depositing charge dQ_C on

5   surface 15, solenoid 20 is used to translate charge source 16 and measuring device 22 by a distance x_0 such that the measuring device 22 is above the surface 15 previously provided with the electric charge dQ_C.

When the electrically conductive body 11 is a semiconductor, the change of the contact potential V measured by the vibrating Kelvin or Monroe electrode is not solely

10   determined by the electric potential difference dV caused by the deposited electric charge dQ_C, but is equal to the change in voltage drop across the dielectric layer dV plus the change in the semiconductor surface barrier, V_{SB}, i.e. $V = dV + V_{SB}$. Preferably, the apparatus 10 further comprises light sources 23, 25, preferably green or blue light emitting diodes, to illuminate testing site 15 during charging (light source 23) and during measuring (light

15   source 25), thereby reducing the value of V_{SB} by collapsing the surface depletion region in case the electrically conducting body 11 is a semiconductor.

The apparatus 10 further comprises a signal processing device 12 which is a computer arranged to receive a signal relating to the electric potential difference. The signal processing device 12 is further arranged to control the high voltage of the charge source 16

20   and the solenoid 20.

After determination of the electrical parameter relating to the electric potential difference dV, the dielectric layer 13 is removed to expose a further surface of the further dielectric layer 3 by an etching step. In one embodiment the dielectric layer 13 is composed of silicon nitride, the further dielectric layer 3 is composed of silicon dioxide and the etching

25   step comprises a wet etch in which phosphoric acid, H_3PO_4, is used as the etching agent. Such an etching process is selective towards silicon nitride, i.e. silicon nitride is removed more effectively than silicon dioxide. The selectivity is improved by heating the etching agent and is usually greater than 25:1. Therefore, the thickness of the exposed part of the further dielectric layer is kept substantially constant during the step of at least partly

30   removing the dielectric layer.

The electrically conductive body 11 thus obtained has only the further dielectric layer 3. In a subsequent step of the method according to the invention a measurement is performed for obtaining measurement data being a further function of the thickness of the at least one further dielectric layer 3. Performing the measurement comprises

the sub-steps of depositing a further electric charge dQ_{CF} onto a further exposed surface of the further dielectric layer 3, thereby inducing a further electric potential difference dV_F between the further exposed surface and the electrically conductive body 11 using the apparatus 10 in an analogous way, followed by determining a further electrical parameter
5   relating to the further electric potential difference dV_F.

The further electric charge dQ_{CF} is deposited by charge source 16 and the further electric potential difference dV_F is determined by the measuring device 22 in way analogous to that described above. The signal processing device 12 is further arranged to receive a further signal relating to the measurement data, and to determine the dielectric layer
10   thickness from the signal and the further signal.

In this embodiment the electrical parameter comprises the electric potential difference dV, the measurement data comprises the further electric potential difference dV_F, and the dielectric layer thickness is derived from the electrical parameter and the measurement data, said dielectric layer thickness being selected from the thickness d_1 of the
15   dielectric layer 13 and the thickness d_2 of the at least one further dielectric layer 3. The dielectric layer 13 has a dielectric constant ε_1, the further dielectric layer 3 has a further dielectric constant ε_2, and the thickness d_1 of the dielectric layer 13 is determined from the thickness d_2 of the further dielectric layer 3, the dielectric constant ε_1, the further dielectric constant ε_2, the electric charge dQ_C and the electrical potential difference dV. To this end, the
20   thickness d_2 of the further dielectric layer 3 is determined from the further electric potential difference dV_F and the further electric charge dQ_{CF} according to the formula $\varepsilon_0\, A/C_F = d_2/\varepsilon_2$, where ε_0 denotes the permittivity of free space and A/C_F is the inverse of the equivalent capacitance density derived from dV_F as a function of dQ_{CF}. Subsequently, the thickness d_1 of the dielectric layer 13 is determined according to the formula $\varepsilon_0\, A/C = (d_1/\varepsilon_1 + d_2/\varepsilon_2)$, where
25   A/C is the inverse of the equivalent capacitance density derived from dV as a function of dQ_C. The signal processing device 12 is arranged to solve these two formulas so as to provide the thickness d_1 and the thickness d_2.

In an alternative embodiment of the method, performing the measurement comprises determining a spectral reflectance of the exposed surface 15 of the dielectric layer
30   13. Alternatively, the spectral reflectance may be determined of the further exposed surface of the further dielectric layer 3. In these cases the thickness d_2 is determined from the measured spectral reflectance in a way analogous to US-4,999,509.

In another embodiment the electrically conductive body 11 and the further dielectric layer 3 are separated by an additional dielectric layer 33 shown in, e.g., Fig. 2A. The method comprises the steps of depositing the electric charge dQ_C on the exposed surface of the dielectric layer 13, determining the electrical parameter relating to the electric potential difference dV, partly removing the dielectric layer 13 to expose the further dielectric layer 3, which results in the structure of Fig. 2B, depositing the further electric charge dQ_{CF} on the exposed surface of the further dielectric layer 3, and determining the further electrical parameter relating to the further electric potential difference dV_F, analogous to the embodiment of the method described above. The method further comprises the steps of partly removing the further dielectric layer 3 to expose the additional dielectric layer 33, which results in the structure of Fig. 2C, depositing an additional electric charge dQ_{CA} on the exposed surface of the additional dielectric layer 33, and determining an additional electrical parameter relating to the additional electric potential difference dV_A. The measurement data comprise the further electric potential difference dV_F and the additional electric potential difference dV_A. The measurement data are a further function of the thickness d_3 of the additional dielectric layer 33. The dielectric layer thickness is selected from the thickness d_1, the thickness d_2 and the thickness d_3, and is derived from the electrical parameter and the measurement data via the following formulas: $\varepsilon_0\ A/C_A = d_3/\varepsilon_3$, $\varepsilon_0\ A/C_F = (d_2/\varepsilon_2 + d_3/\varepsilon_3)$ and ε_0 $A/C = (d_1/\varepsilon_1 + d_2/\varepsilon_2 + d_3/\varepsilon_3)$, where ε_3 denotes the dielectric constant of the additional layer 33. Here, A/C is the inverse of the equivalent capacitance density derived from dV and dQ_C, A/C_F is the inverse of the equivalent capacitance density derived from dV_F and dQ_{CF}, and A/C_A is the inverse of the equivalent capacitance density derived from dV_A and dQ_{CA}.

In an alternative embodiment of the method, performing the measurement comprises determining a spectral reflectance of the exposed surface 15 of the dielectric layer 13. Alternatively, the spectral reflectance may be determined of the further exposed surface 15' of the further dielectric layer 3 and/or of the additional exposed surface 15" of the additional dielectric layer 33 shown in Figs. 2B and 2C, respectively. In these cases the thickness d_2 and/or the thickness d_3 are determined from the measured spectral reflectance in a way analogous to US-4,999,509.

The method of manufacturing an electric device 100 according to the invention comprises the steps of providing the electrically conductive body 11 with the further dielectric layer 3, providing the further dielectric layer 3 with the dielectric layer 13, and performing the method for determining the dielectric layer thickness according to the invention. In the embodiment shown in Figs. 2A–2D the electrically conductive body 11 is a

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monocrystalline silicon wafer which prior to providing the further dielectric layer 3 is provided with the additional layer 33. After having provided the dielectric layer 13 the exposed surface is provided with a layer of polycrystalline silicon which is subsequently patterned to form the gate layer 2 shown in Fig. 2A. Subsequently, the method for

5   determining the dielectric layer thickness as described above is performed for monitoring the steps of providing the electrically conductive body 11 with the further dielectric layer 3 and/or of providing the further dielectric layer 3 with the dielectric layer 13. To this end the charge dQ_C is deposited on surface 15 of layer 13 shown in Fig. 2A and the resulting electric potential difference dV is determined. Subsequently, part of the dielectric layer 13 is

10   removed to expose surface 15' of the further dielectric layer 3, shown in Fig. 2B, and the further charge dQ_{CF} is deposited on surface 15' and the resulting further electric potential difference dV_F is determined. In a next step part of the further dielectric layer 3 is removed to expose surface 15" of the additional dielectric layer 33, shown in Fig. 2C, and the further charge dQ_{CA} is deposited on surface 15" and the resulting further electric potential difference

15   dV_A is determined. Finally, the additional dielectric layer 33 is partly removed to expose the electrically conducting body 11, and adjacent to the stack thus formed a source region 50 and a drain region 51 are formed by implanting ions.

The electric device 100 obtained in this way and shown in Fig. 2D is a transistor. It comprises an electrically conductive body 11 having the dielectric layer 13, the

20   dielectric layer 13 being separated from the electrically conductive body 11 by at least a further dielectric layer 3.

In summary, the method for determining the thickness of a dielectric layer according to the invention comprises the step of providing an electrically conductive body 11 having a dielectric layer 13 which is separated from the electrically conductive body 11 by at

25   least a further dielectric layer 3 and a surface 15 of which is exposed. Onto the exposed surface 15 an electric charge is deposited, thereby inducing an electric potential difference between the exposed surface 15 and the electrically conductive body 11. An electrical parameter relating to the electric potential difference is determined and a measurement is performed to obtain additional measurement data relating to the thickness of the dielectric

30   layer 13 and/or to the thickness of the further dielectric layer 3. In this way the thickness of the dielectric layer 13 and/or of the further dielectric layer 3 is determined. The method of manufacturing an electric device 100 comprises this method for determining the thickness of a dielectric layer. The apparatus 10 for determining the thickness of a dielectric layer is arranged to execute this method.

It should be noted that the above-mentioned embodiments illustrate rather than limit the invention, and that those skilled in the art will be able to design many alternative embodiments without departing from the scope of the appended claims. In the claims, any reference signs placed between parentheses shall not be construed as limiting the claim. The word "comprising" does not exclude the presence of elements or steps other than those listed in a claim. The word "a" or "an" preceding an element does not exclude the presence of a plurality of such elements.